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## The Effect of Augmented Reality-Assisted Project-Based Learning (PjBL) on Conceptual Understanding in IPAS (Natural and Social Sciences)


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### Kata Kunci:

*Project Based Learning (PjBL), Augmented Reality (AR), Pemahaman Konsep, IPAS*

**Abstrak:** Berangkat dari permasalahan rendahnya pemahaman konsep IPAS siswa yang disebabkan oleh pembelajaran teoretis dan berpusat pada guru, penelitian ini menguji sebuah solusi inovatif. Studi ini bertujuan menganalisis dampak signifikan dari penerapan model Project Based Learning (PjBL) dengan dukungan media Augmented Reality (AR). Menggunakan metode kuantitatif berdesain quasi-experimental, penelitian ini membandingkan hasil belajar antara kelompok eksperimen (diberi perlakuan PjBL-AR) dan kelompok kontrol (metode konvensional) pada 46 siswa kelas IV SD Negeri 2 Sukarame. Pengumpulan data dilaksanakan dari 11 Agustus hingga 17 September 2025 menggunakan instrumen tes uraian yang valid dan reliabel. Karena sebaran data kelompok kontrol tidak normal, uji hipotesis dilakukan dengan Mann-Whitney U. Temuan penelitian memperlihatkan perbedaan statistik yang sangat jelas: rata-rata nilai kelompok eksperimen mencapai 80,35, jauh melampaui kelompok kontrol yang hanya 64,57 (Asymp. Sig. 0.000 < 0.05). Hasil ini mengonfirmasi penolakan  $H_0$  dan membuktikan bahwa PjBL berbantuan AR secara efektif mampu meningkatkan pemahaman konsep siswa pada mata pelajaran IPAS.

**Keywords:** *Project Based Learning (PjBL), Augmented*

**Abstract:** *Addressing the issue of low conceptual understanding in IPAS, which stems from theoretical, teacher-centered instruction, this research tested an innovative solution. The study aimed to analyze the*

Reality (AR), Conceptual Understanding, IPAS

significant impact of implementing a Project-Based Learning (PjBL) model supported by Augmented Reality (AR) media. Employing a quantitative, quasi-experimental design, this research compared the learning outcomes between an experimental group (receiving the PjBL-AR treatment) and a control group (using conventional methods) among 46 fourth-grade students at SD Negeri 2 Sukarame. Data collection occurred from August 11 to September 17, 2025, using a validated and reliable essay test instrument. Due to the non-normal distribution of the control group's data, the hypothesis was tested using the Mann-Whitney U test. The findings revealed a statistically clear difference: the experimental group's mean score reached 80.35, far surpassing the control group's score of 64.57 (Asymp. Sig.  $0.000 < 0.05$ ). This result confirms the rejection of  $H_0$  and proves that AR-assisted PjBL can effectively enhance students' conceptual understanding in the IPAS subject.

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## INTRODUCTION

To produce quality human resources who can adapt to a developing world, 21st-century education requires a commitment to innovation (Rahman et al., 2024). A significant challenge that persists in the Indonesian education system is its reliance on conventional, teacher-dominated instructional methods. This approach often limits students to a passive role of information intake, hindering their active engagement in building knowledge and ultimately impairing their conceptual understanding (Fauzia & Kelana, 2020). Conceptual understanding itself is a crucial competency, defined not by the ability to simply recall facts, but to explain, classify, and utilize that knowledge in new contexts.

A preliminary investigation in the fourth-grade class at SD Negeri 2 Sukarame has identified poor conceptual understanding among students in the Natural and Social Sciences (IPAS) subject, a course designed to holistically link natural and social concepts. Classroom observations and teacher interviews confirm this issue, with the average student score at 64.57, well below the school's Minimum Mastery Criterion (KKM) of 70. This performance gap affects 65% of the students, who demonstrate significant trouble with abstract topics such as the relationship between ecosystem components and changes in the states of matter. The root cause appears to be a reliance on conventional, non-participatory teaching methods. As a result, most students are unable to articulate concepts independently, classify objects, or present information in different formats like diagrams, which points to a learning environment that prioritizes memorization over deep, meaningful understanding.

While previous research has established that the implementation of Project-Based Learning (PjBL) can enhance student learning outcomes and critical thinking skills (Fitriani et al., 2022; Rahman & Sari, 2023), a significant gap exists wherein the majority of these studies have not integrated this model with Augmented Reality (AR) media. AR technology offers a unique capability to facilitate a more concrete and interactive visualization of abstract concepts for students. Furthermore, prior research has typically focused on either science (IPA) or social studies (IPS) as separate disciplines, whereas the Merdeka curriculum has since integrated them into the unified subject of Natural and Social Sciences (IPAS). Consequently, the novelty of this study lies in its integration of an AR-assisted PjBL model within the context of elementary school IPAS instruction, with a specific focus on elevating students' conceptual understanding.

To address these challenges, an instructional model capable of actively constructing student comprehension is necessary. Project-Based Learning (PjBL) stands out as an innovative, student-centered pedagogical approach wherein students engage in a deep investigation of a particular topic through the execution of a project (Nababan et al., 2023). This model fundamentally encourages students to work collaboratively, solve problems, and produce tangible artifacts, which in turn makes the learning process more meaningful and contextual (Fathonah et al., 2023). An extensive body of research confirms the efficacy of PjBL, demonstrating its effectiveness in enhancing motivation

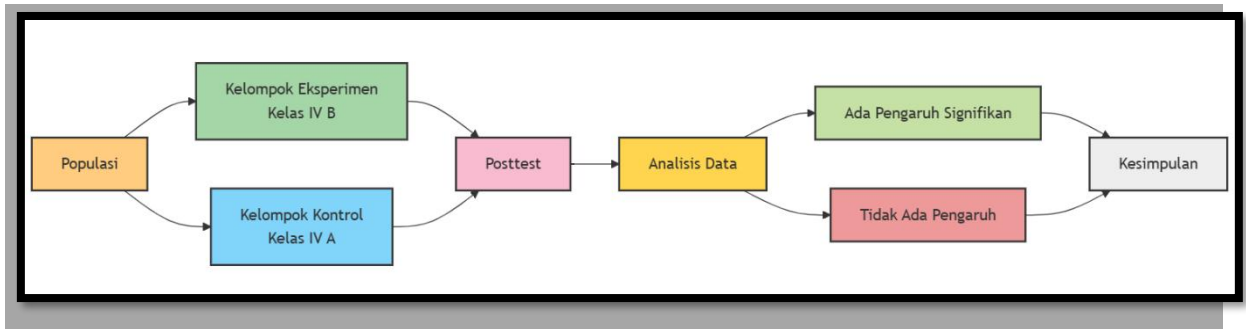
(Işık & Gücüm, 2013), creativity (Sari & Angreni, 2018), collaborative skills (Purnomo et al., 2024), and overall student learning outcomes (Hakim et al., 2021).

Concurrently, advancements in technology present viable solutions for the challenge of visualizing abstract concepts. Augmented Reality (AR) is defined as a technology capable of integrating two or three-dimensional virtual objects into a real-world environment in real-time (Nuraini, 2023). Within an educational context, AR can transform traditional materials, such as textbooks or printed media, into interactive objects that students can explore. This process renders complex subject matter, like the water cycle or the solar system, significantly more comprehensible (Wijaya & Purwati, 2024). Consequently, the application of AR has been empirically shown to be effective in enhancing student interest, engagement, and conceptual understanding (Wati et al., 2025).

A powerful synergy emerges from integrating the Project-Based Learning (PjBL) model with Augmented Reality (AR) media, fostering a pedagogical environment that is highly interactive, collaborative, and uniquely capable of rendering abstract concepts tangible. While a body of literature affirms the efficacy of PjBL in developing higher-order thinking skills like creativity (Chintya et al., 2023) and critical inquiry (Ramadhani et al., 2025), and separate studies confirm AR's capacity to boost conceptual understanding (Indriani et al., 2023), a scholarly lacuna exists. Specifically, there is a scarcity of research that synthesizes these two powerful tools to improve IPAS comprehension among elementary students. This study, therefore, was designed to address this gap by quantitatively evaluating the statistical significance of an AR-assisted PjBL intervention on the conceptual understanding of fourth-grade students in the IPAS subject. To guide the analysis, two opposing hypotheses were formulated. The null hypothesis ( $H_0$ ) proposed that no statistically significant distinction would be found in conceptual understanding between students in the AR-assisted PjBL program and their peers in a conventional learning environment. Conversely, the alternative hypothesis ( $H_1$ ) asserted that a significant disparity in conceptual understanding would exist between the group engaged with the AR-PjBL model and the group receiving traditional instruction.

## METHOD

This study employed a quantitative approach, utilizing a Quasi-Experimental design of the Posttest-Only Control Group type. This particular design was selected for its utility in comparing the effects of an intervention between two groups that were not fully randomized (Sugiyono, 2018). The research was conducted during the odd semester of the 2025/2026 academic year at SD Negeri 2 Sukarame, located in Bandar Lampung



**Figure 1. Research Design**

The population for this study comprised the entire fourth-grade cohort at SD Negeri 2 Sukarame, which consisted of 70 students. The research sample was composed of two distinct classes: class IV B (23 students) was designated as the experimental group, while class IV A (23 students) served as the control group. A nonprobability sampling technique was utilized for this selection, a choice justified by the balanced number of students in both classes. The experimental group received the treatment, consisting of the Project-Based Learning (PjBL) model supported by Augmented Reality (AR) media, whereas the control group was instructed using a direct (conventional) teaching model.

The research instrument utilized to measure students' conceptual understanding was an essay-based posttest. The test items were developed based on a blueprint encompassing five key indicators of conceptual understanding: restating, classifying, providing examples, presenting in an alternative form, and developing the necessary conditions of a concept. Prior to its main application, the instrument was trialed on 20 students outside the research sample to establish its validity and reliability. A validity analysis was conducted using the Pearson Product Moment correlation, which determined that 10 out of the 15 initial items were valid, as their calculated r-value surpassed the r-table value of 0.444. Furthermore, a reliability test using Cronbach's Alpha yielded a coefficient of 0.812, indicating that the instrument was highly reliable.

The statistical procedures for this research comprised descriptive and inferential analyses. Preceding the main hypothesis test, a Shapiro-Wilk test was performed to evaluate the distribution of the data. The results showed that the scores from the control group did not adhere to a normal distribution. Given this violation of a key assumption for parametric analysis, the research hypothesis was evaluated using the non-parametric Mann-Whitney U test. This statistical procedure was specifically utilized to determine if a significant difference in conceptual understanding emerged between the experimental and control groups after the conclusion of the treatment phase.

**Table 1. Instrument Validity Test**

Item	r_calculated	r_table	Description
1	-0.04	0.444	Invalid
2	-0.06	0.444	Invalid
3	0.50	0.444	Valid
4	0.08	0.444	Invalid
5	0.50	0.444	Valid
6	0.50	0.444	Valid
7	0.33	0.444	Invalid
8	0.50	0.444	Valid
9	0.18	0.444	Invalid
10	0.50	0.444	Valid
11	0.50	0.444	Valid
12	0.50	0.444	Valid
13	0.50	0.444	Valid
14	0.50	0.444	Valid
15	0.50	0.444	Valid

As presented in Table 1, the results of the instrument validity test. The findings indicate that out of fifteen items, several did not meet the validity criteria, as their calculated correlation coefficients ( $r_{\text{calculated}}$ ) were lower than the critical value of  $r_{\text{table}} = 0.444$ . Meanwhile, items with  $r_{\text{calculated}}$  values equal to or greater than the  $r_{\text{table}}$  threshold were categorized as valid, demonstrating that these statements are capable of accurately measuring the intended constructs within the research instrument.

**Table 2. Instrument Reliability Test**

Cronbach's Alpha	N of Items
.812	10

The reliability analysis for the 10 validated items yielded a Cronbach's Alpha coefficient of 0.812. As this value is greater than the commonly accepted threshold of 0.70, the instrument was thereby confirmed to be reliable and internally consistent for the purposes of this research.

## RESULTS AND DISCUSSION

This study yielded quantitative data derived from the posttest scores measuring students' conceptual understanding following the implementation of the respective treatments. The results of the statistical analyses conducted on this data are presented below.

**Table 3. Results of the Normality Test**

	GroupNum	Kolmogorov-Smirnov <sup>a</sup>			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Skor_Posttest	1	.168	23	.089	.931	23	.117
	2	.167	23	.097	.890	23	.016

The normality assessment, detailed in Table 3, revealed differing distributions between the two groups. For the experimental group (Group 1), the data were found to be normally distributed, a conclusion supported by significance values from both the Kolmogorov-Smirnov test ( $p = 0.089$ ) and the Shapiro-Wilk test ( $p = 0.117$ ), both of which surpassed the 0.05 alpha level. Conversely, the data for the control group (Group 2) did not meet the assumption of normality. Although the Kolmogorov-Smirnov test suggested normality ( $p = 0.097$ ), the more sensitive Shapiro-Wilk test yielded a statistically significant result ( $p = 0.016$ ), indicating a deviation from a normal distribution. As a prerequisite for hypothesis testing, an analysis of the homogeneity of variances was then performed using Levene's Test, with the results summarized in the following Table 4.

**Table 4. Results of the Homogeneity of Variance Test**

		Levene	df1	df2	Sig.
		Statistic			
Skor_Posttest	Based on Mean	4.732	1	44	.035
	Based on Median	4.272	1	44	.045
	Based on Median and with adjusted df	4.272	1	32.974	.047
	Based on trimmed mean	4.406	1	44	.042

As indicated by the results in Table 4, all bases for the Levene's test calculation yielded significance values below the 0.05 threshold, with values ranging from 0.035 to 0.047. This finding demonstrates that the variances between the experimental and control groups are not homogeneous. Consequently, a key assumption for parametric testing—homogeneity of variances—was not met. Given this violation, the hypothesis for this research was not tested using a parametric t-test. Given the data's failure to meet key parametric assumptions, the non-parametric Mann-Whitney U test was selected for the primary analysis. This statistical procedure is appropriate as it is not contingent upon the data being normally distributed or possessing equal variances. Its application in this context was to evaluate whether a statistically significant disparity existed in conceptual understanding between the experimental group, which was exposed to the AR-assisted PjBL model, and the control group, which received traditional instruction. The outcomes of this SPSS analysis are presented below:

**Table 5. Results of the Mann-Whitney Test on Students' Conceptual Understanding Independent-Samples Mann-Whitney U Test**

Summary	
Total N	46
Mann-Whitney U	469.000
Wilcoxon W	745.000
Test Statistic	469.000
Standard Error	43.863
Standardized Test Statistic	4.662
Asymptotic Sig. (2-sided test)	.000

Based on the data presented in Table 5, the obtained Asymp. Sig. (2-tailed) value is 0.000, which is less than the significance level of 0.05. This result indicates a statistically significant difference between the posttest scores for conceptual understanding in the experimental group and the control group. Consequently, the null hypothesis ( $H_0$ ), which posited no difference in conceptual understanding between the two groups, is rejected, and the alternative hypothesis ( $H_1$ ) is accepted.

These results provide a clear demonstration that the integration of the AR-assisted PjBL model is a highly effective strategy for enhancing students' conceptual grasp of IPAS. The significant outperformance of the experimental group over the control group on the posttest serves as direct validation of this effect. This finding lends strong support to the principles of constructivism, which holds that understanding is not passively received but is actively generated by learners as they engage with their environment and participate in direct, experiential activities

This study's findings provide compelling evidence that integrating Augmented Reality (AR) media with a Project-Based Learning (PjBL) framework significantly improves the conceptual understanding of IPAS for fourth-grade students. This conclusion is quantitatively supported by the marked difference in posttest scores, where the experimental group's average (80.35) far surpassed that of the control group (64.57), indicating the creation of a superior learning environment. This result aligns with constructivist principles, which argue that knowledge is actively built by learners through interaction and experience rather than passively absorbed. PjBL serves as a catalyst for this active construction, placing students at the core of the educational process by involving them in authentic investigation, problem-solving, and project development (Syahlan et al., 2023; Wahyu, 2018).

The superiority of the PjBL model in enhancing conceptual understanding is substantiated by a significant body of prior research. PjBL compels students to develop higher-order thinking skills, such as analysis, synthesis, and evaluation, as they are

required to complete complex tasks (Dole et al., 2017). In the context of this study, students did not merely learn the theory of the water cycle; they applied it within a project, which fostered a deeper and more lasting comprehension. This outcome is consistent with the findings of Roosyanti & Suryarini (2024) and Rasyid et al. (2023), whose research demonstrated that a PjBL model integrated with a STEM approach effectively improved students' problem-solving abilities.

Furthermore, the contribution of Augmented Reality (AR) media to this success cannot be overstated. IPAS subject matter, such as the water cycle, is often abstract and difficult for elementary school students, who are still in the concrete operational stage of cognitive development, to visualize. AR serves as a crucial visual bridge, transforming these abstract concepts into interactive and engaging three-dimensional representations (Nuraini, 2023). Through their devices, students could directly observe simulations of evaporation, condensation, and precipitation, which significantly reinforced their conceptual understanding. This finding is corroborated by research from Indriani et al. (2023), Ramadhani et al. (2025), and Wati et al. (2025), all of whom concluded that AR is effective in visualizing complex material and improving learning outcomes.

The integration of PjBL and AR effectively fosters a holistic learning ecosystem. In this system, PjBL provides the pedagogical framework that promotes activity, collaboration, and learner autonomy (Rizal et al., 2025), while AR supplies the technological tool that renders the learning process more immersive and comprehensible. This synergy directly addresses the core demands of 21st-century education, which call for a seamless integration of technology, pedagogy, and content knowledge (TPACK). Notwithstanding the significant success demonstrated in this study, several implementation challenges were noted, including initial technical difficulties with the AR application and the necessity for intensive guidance from the teacher (Syahlan et al., 2023). These challenges underscore the critical importance of both teacher preparedness and adequate school infrastructure to fully maximize the potential of this innovative instructional model.

## CONCLUSION

Based on the data analysis conducted using the non-parametric Mann-Whitney U test, an Asymp. Sig. (2-tailed) value of 0.000 was obtained. As this value is less than the significance level of 0.05, it indicates a statistically significant difference between the experimental and control groups. The mean posttest score for students in the experimental group was 80.35, whereas the control group achieved a mean score of only 64.57. This outcome demonstrates that students who participated in learning through the Augmented Reality (AR) assisted Project-Based Learning (PjBL) model possess a superior conceptual understanding compared to those instructed via conventional methods. Therefore, the null hypothesis ( $H_0$ ) is rejected, and the alternative hypothesis ( $H_1$ ) is accepted. It can thus be concluded that the application of the AR-assisted PjBL model has a significant positive effect on the IPAS conceptual understanding of fourth-grade elementary school students.

This finding reinforces the view that Project-Based Learning (PjBL) effectively encourages students to actively construct knowledge through direct experience and project-based inquiry. Simultaneously, Augmented Reality (AR) media serves as a powerful tool to visualize abstract IPAS concepts, rendering them more concrete, interactive, and engaging. The synergy between the PjBL model and AR media cultivates a learning environment that is contextual, collaborative, and student-centered. This approach aligns seamlessly with the principles of 21st-century learning and constructivist theory, both of which emphasize the active involvement of students in building their own conceptual understanding. Therefore, the application of AR-assisted PjBL can be considered an innovative alternative for enhancing the quality of IPAS instruction in elementary schools, particularly within the context of the Merdeka Curriculum, which advocates for project-based and digitally-integrated learning.

Despite the positive outcomes obtained, this study has several limitations that warrant consideration. First, the research was conducted at a single institution, SD Negeri 2 Sukarame, with a limited sample size; therefore, the findings may not be generalizable to a broader population. Second, the relatively short duration of the research, which ran from August 11 to September 17, 2025, meant that the measurement of learning impact was confined to short-term outcomes, without assessing the long-term retention of students' conceptual understanding. Third, the study's focus was exclusively on the aspect of conceptual understanding, thereby not encompassing other learning dimensions such as critical thinking, problem-solving, collaboration, or scientific attitudes.

Considering these limitations, it is recommended that future research be conducted with a more diverse population across various locations and over a more extended instructional period. Furthermore, subsequent studies should incorporate additional learning outcomes relevant to the Pancasila Student Profile. Future research could also explore the long-term effectiveness of the AR-assisted PjBL model across different IPAS topics or other subjects, thereby enriching the empirical evidence regarding the integration of project-based models and augmented reality (AR) technology in elementary education.

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